TRC Environmental Corporation

REPORT

MODELING ANALYSES FOR SO_2 NAAQS COMPLIANCE FOR WARREN GENERATING STATION

SUPPLEMENT

Prepared for

GPU Generation Corporation
(formerly Pennsylvania Electric Company)
Johnstown, Pennsylvania

Prepared by

TRC Environmental Corporation
Windsor, Connecticut

May 7, 1996

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May 7, 1996

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1.0 INTRODUCTION

This report presents the results of dispersion modeling analyses that have been performed to demonstrate compliance with the sulfur dioxide (SO_2) National Ambient Air Quality Standards (NAAQS) in the vicinity of Warren Generating Station in Warren, Pennsylvania. Warren Station is operated by GPU Generation Corporation (GPU Genco), formerly the Pennsylvania Electric Company (Penelec). The compliance demonstration also involves the SO_2 emissions of another major nearby source, the United Refining Company.

The dispersion modeling analyses described herein were conducted to support a revised State Implementation Plan (SIP) for Conewango, Glade and Pleasant Townships and the City of Warren in Warren County, Pennsylvania. The revised SIP will contain the SO_2 emission rate limits required to meet the NAAQS in Warren County.

This report supplements an October 27, 1994 TRC Environmental Corporation (TRC) report which presented the results of previous SO_2 compliance dispersion modeling analyses for Warren Station (TRC, 1994b). This supplement addresses concerns raised by the U. S. Environmental Protection Agency (EPA) in letters to the Pennsylvania Department of Environmental Protection (DEP) dated June 19, 1995 (from Ms. Makeba Morris to Mr. James Salvaggio) and October 25, 1995 (from Mr. Denis Lohman to Ms. Jane Mahinske) regarding the previous report.

The major concerns raised by EPA involved 1) the determination of representative background concentrations and 2) the resolution of differences between the TRC modeling results and subsequent modeling results obtained (in January 1995) by DEP (DEP, 1995). The TRC and DEP analyses were performed using different models, stack parameter data, receptors and meteorological data. Procedures for resolving these issues were discussed at a meeting on

February 14, 1996, and approval to proceed with revised analyses was obtained in an April 4, 1996 letter from DEP to GPU Genco (from Ms. Jane Mahinske to Mr. Keith Schmidt).

The following sections of this report describe the dispersion modeling analyses, the determination of revised background concentrations and the development of revised SO_2 emission rate limits based on the combined use of the TRC and DEP modeling analysis results.

2.0 COMPLIANCE DISPERSION MODELING ANALYSES

The approved procedure for determining appropriate emission rate limits for Warren County is based on dispersion modeling analyses performed by both TRC and DEP. The TRC analyses were performed using primarily the Large Area Power Plant Effluent Study (LAPPES) model for Warren Station and the Rough Terrain Diffusion Model (RTDM) for United Refining (Slowick, 1970; ERT, 1987). The DEP analyses were performed using only the screening version of the Complex Terrain Dispersion Model Plus Algorithms for Unstable Situations (CTSCREEN) for both facilities (EPA, 1989). Other important differences between the TRC and DEP modeling analyses included:

- the TRC modeling was performed using a higher SO_2 emission rate for Warren Station,
- the DEP modeling was performed using a larger number of sources and a lower total SO_2 emission rate for the United Refining facility,
- the areas modeled were not identical and the specific receptors did not coincide,
- the DEP modeling did not include Warren Station for all receptors, and
- one year of on-site meteorological data was used by TRC; DEP used the required built-in array of hypothetical meteorological data in CTSCREEN.

In previous model performance comparisons conducted for Warren Station and other GPU Genco operated power plants, RTDM has been shown to greatly overpredict actual ambient SO_2 concentrations in complex terrain (TRC, 1994a, TRC, 1993). It is therefore preferable to set emission rate limits for Warren Station using LAPPES and CTSCREEN.

2.1 Discussion of the TRC and DEP Analyses

The TRC modeling analyses were performed using an SO_2 emission rate of 4.0 lbs per million British thermal units (lb/MMBtu) of heat input for Warren Station. The objective of the TRC analyses was to determine the maximum allowable SO_2 emission rate for Warren Station that would

result in compliance with the NAAQS. The DEP modeling was performed using an SO_2 emission rate of 3.2 lbs/MMBtu for Warren Station.

Table 2-1 shows a comparison of the source parameter data used by TRC and DEP to model United Refining. The table shows that the total SO_2 emissions used by TRC were higher than those used by DEP, so TRC's modeling analyses were more conservative than DEP's. It was therefore concluded that TRC's modeling analyses are acceptable for use in the final compliance modeling analyses for Warren County.

The TRC modeling analyses were limited to the hills near Warren Station but included hills that are located:

- northeast of Warren Station and northwest of United Refining (hereinafter referred to as the Washington Park hills, see Figure 2-1), and
- east southeast of Warren Station and west, southwest and south of United Refining (hereinafter referred to as the St. Joseph/Oakland cemeteries hills, see Figure 2-2).

DEP did not perform any CTSCREEN modeling analyses of the Washington Park hills, and DEP's CTSCREEN modeling analyses of the St. Joseph/Oakland cemeteries hills only included the United Refining sources. DEP concluded that the potential for overlapping impacts from Warren Station and United Refining was minimal on these hills. The St. Joseph/Oakland cemeteries hills correspond to DEP CTSCREEN hill numbers 1 and 2. DEP only included Warren Station in CTSCREEN modeling performed for other hills that are to the north, northeast and east of both United Refining and Warren Station (i.e., DEP CTSCREEN hill numbers 3, 4 and 5).

The Washington Park hills include TRC receptor numbers 147 through 164, while the St. Joseph/Oakland cemeteries hills include TRC receptor numbers 165 through 180. TRC receptor numbers 165 through 174 are located on DEP CTSCREEN hill No. 1 and TRC receptor numbers 175, 179 and 180 are located on DEP CTSCREEN hill No. 2.

Table 2-1
Comparison of Emission Inventories for United Refining

ID	Source Name	SO_2 Emission Rate (g/s) GPU Genco Modeling	SO_2 Emission Rate (g/s) PaDEP Modeling	Stack Height (m) GPU Genco Modeling	Stack Height (m) DEP Modeling	Stack Diameter (m) GPU Genco Modeling	Stack Diameter (m) DEP Modeling	Stack Exit Velocity (m/s) GPU Genco Modeling	Stack Exit Velocity (m/s) DEP Modeling	Stack Exit Temperature (K) GPU Genco Modeling	Stack Exit Temperature (K) DEP Modeling
A	Boiler House	28.73	24.58	68.58	68.58	2.44	2.44	11.44	11.44	672.0	672.0
B	No. 4 Boiler	1.64	3.06	45.72	45.72	1.70	1.70	12.37	12.37	505.4	505.4
C	FCC Charge Heater	1.89	0.14	38.10	38.10	1.22	1.22	10.51	10.51	560.9	560.9
D	DHT1 Heater	0.13	0.01	30.48	30.48	0.91	0.91	3.88	3.88	922.0	922.0
E	Prefract Reboiler (East)	0.44	1.13	12.19	12.19	0.61	0.61	10.03	10.03	699.8	699.8
F	Prefract Reboiler (West)	0.44	1.13	12.19	12.19	0.61	0.61	10.03	10.03	699.8	699.8
G	Old Reformer Heater	8.44	11.50	45.72	45.72	1.89	1.89	10.43	10.42	699.8	699.8
H	Crude (WHECO) Heater	32.51	26.27	45.72	45.72	2.59	2.59	15.09	15.05	699.8	699.8
I	Pretreater Heater	1.76	3.53	51.82	51.82	1.89	1.89	3.84	3.84	588.7	588.7
J	New Reformer Heater	1.13	0.28	45.72	45.72	2.13	2.13	6.65	6.64	533.2	533.2
K	Debut Reboiler	0.25	0.05	30.48	30.48	0.85	0.85	12.70	12.79	922.0	922.0
L	FCC Regenerator	42.46	35.91	45.72	45.72	2.13	2.13	15.21	15.21	533.2	533.2
M	Combo Flare (Blowdown)		0.05		7.32		3.05		2.00		1255.0
N	FCC Flare (Blowdown)		0.01		10.67		3.35		0.42		1255.0
O	No. 5 Boiler	0.25	0.15	30.48	30.48	1.22	1.22	12.05	12.05	588.7	588.7
Q	Saturated Gas KVG		0.01		7.62		0.25		20.49		644.3
U	T-241 Heater		0.04		12.19		0.76		8.58		644.3
V	DHT2 Heater (New)		4.21		30.48		1.07		11.35		714.0
W	SRU Incinerator (New)		1.51		38.10		0.76		18.94		922.0
	Totals	120.07	113.57								

Shaded areas indicate differences between the two modeling analyses. TRC's analyses on behalf of GPU Genco were probably conservative because the total SO_2 emission rate for United Refining was greater than that used by DEP. The other stack parameter differences between the two analyses are minor. Similar minor differences exist in some stack location coordinates. The DEP data were obtained from Table 5 in DEP's January 3, 1995 modeling report.

Figure 2-1

Warren Compliance Receptor Grid (Northeast Quadrant)

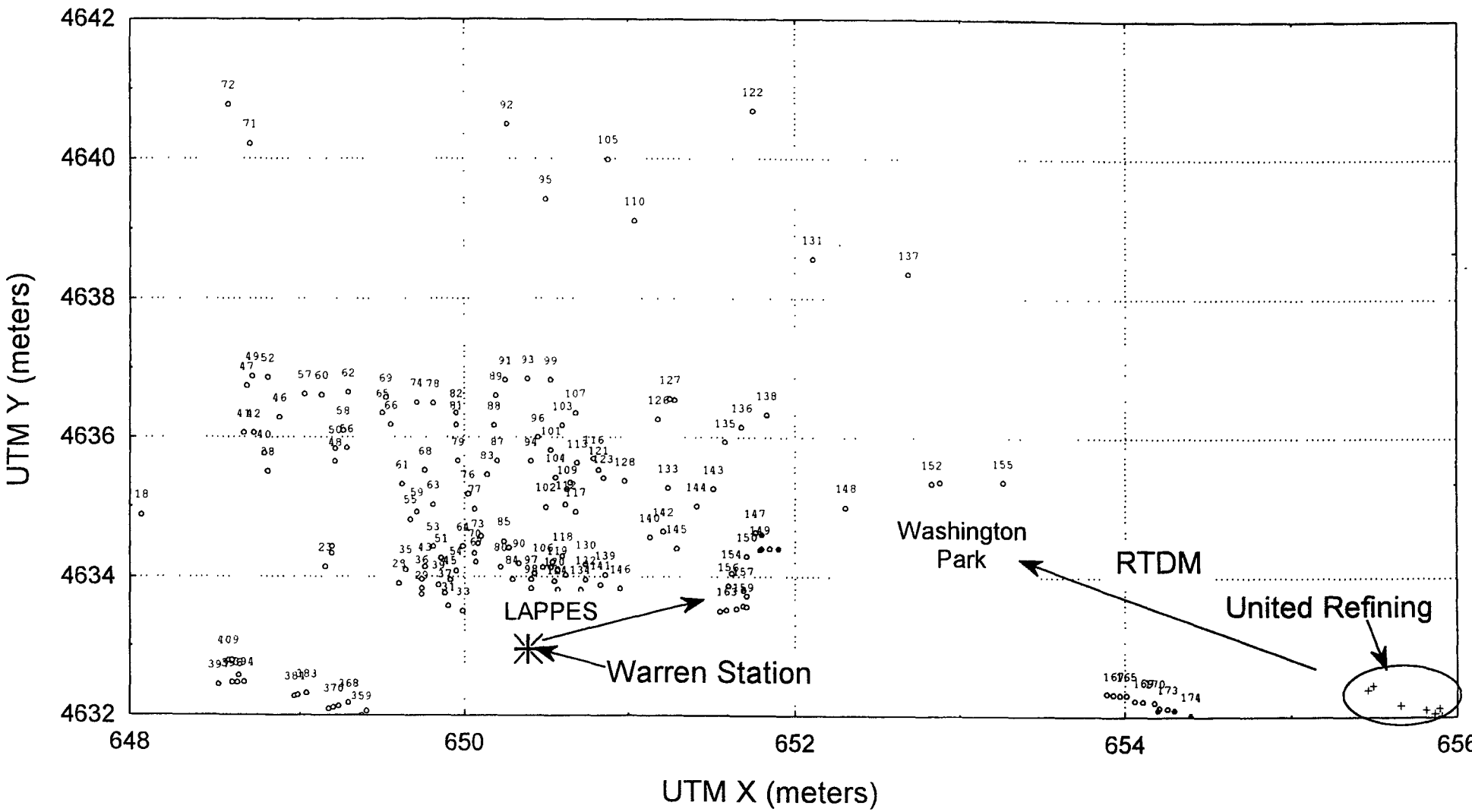
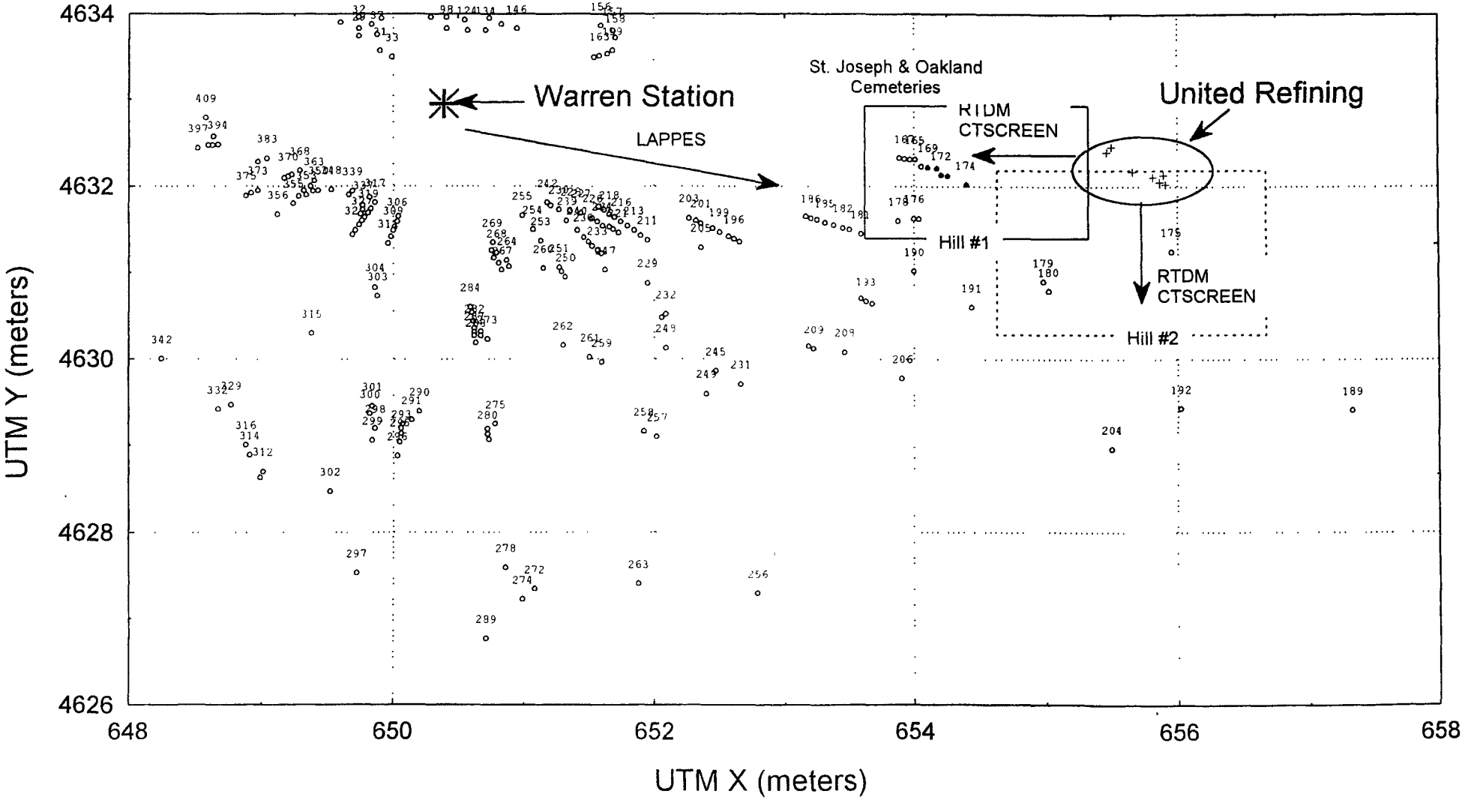


Figure 2-2

Warren Compliance Receptor Grid (Southeast Quadrant)



The receptor location information was needed to make comparisons between the impacts predicted by RTDM and CTSCREEN for the United Refining sources. For a location where both models produced predicted impacts of the United Refining sources, it was expected that CTSCREEN would provide more reliable estimates than RTDM.

2.2 Application of the TRC and DEP Analyses

Based on the information discussed above, all three models (i.e., LAPPES, CTSCREEN and RTDM) have been used to determine the maximum total SO_2 concentrations produced by Warren Station and United Refining. The maximum concentrations were calculated using a hybrid set of results from the three models. The procedure used was based on the conclusion that all the receptors and averaging periods with potential violations of the SO_2 NAAQS were identified by the TRC modeling analyses with LAPPES and RTDM. The following steps were then followed to eliminate any violations attributable to overpredictions by RTDM.

- the maximum impacts of Warren Station were defined by LAPPES at all receptors where LAPPES modeling results were available,
- the maximum impacts of Warren Station were defined by CTSCREEN at all other receptors,
- the maximum impacts of United Refining were defined by CTSCREEN at all receptors where CTSCREEN modeling results were available, and
- the maximum impacts of United Refining were defined by RTDM at all other receptors.

The method used to substitute the concentrations predicted by CTSCREEN for those predicted by RTDM varied depending on the averaging period. For the 3-hour averaging period, the individual source contributions were first determined on an hourly basis for LAPPES, RTDM and CTSCREEN. If a given hourly impact was attributable to Warren Station, the value predicted by

LAPPES was left unchanged. If a given hourly impact was attributable to United Refining (based on a review of the meteorological data), the value predicted by RTDM was replaced by the value predicted by CTSCREEN. Following the substitution of the hourly values, the 3-hour average concentrations were re-calculated for comparison to the NAAQS.

For the 24-hour and annual averaging periods, the United Refining impacts predicted by RTDM were replaced by those predicted by CTSCREEN without regard to the individual hourly average concentrations. This method produced reliable predictions of the maximum impacts of United Refining without having to determine the degree to which United Refining contributed to each hourly average concentration.

The preceding procedure was approved by DEP in the April 4, 1996 letter to GPU Genco (from Ms. Jane Mahinske to Mr. Keith Schmidt).

3.0 REVISED BACKGROUND CONCENTRATIONS

Background air pollutant concentrations are defined as those concentrations attributable to all sources that are not included in the dispersion modeling analyses. In this case, that means all emission sources other than Warren Station and United Refining. When TRC's October 1994 report was in preparation, TRC concluded that the best estimate of each hourly background concentration was the minimum measured value from among the available monitoring sites because there was considerable uncertainty regarding the degree to which upset conditions at United Refining contributed to the measured SO_2 concentrations. Agreement has since been reached to exclude the upset events identified by DEP from the calculation of background concentrations.

The revised procedure used to determine appropriate background concentrations follows the guidance contained in Section 9.2 of Supplement B to EPA's Guideline on Air Quality Models (EPA, 1994). The EPA guidance is general in nature and is adaptable to site-specific situations. The specific procedure used for this analysis was approved by DEP in the April 4, 1996 letter to GPU Genco (from Ms. Jane Mahinske to Mr. Keith Schmidt).

TRC developed the revised background concentrations using the ambient SO_2 and meteorological data obtained by GPU Genco during the period from March 1, 1993 through February 28, 1994. These are the same data that were used in the model performance evaluation study for Warren Station (TRC, May 1994a). The SO_2 data were collected at a network of seven monitoring sites located in various directions around Warren Station (see Figures 3-1 and 3-2).

In accordance with the EPA guidance, TRC has now determined background concentrations as a function of the measured meteorological conditions. This was accomplished using the set of 36 categories of meteorological conditions shown in Table 3-1. The meteorological categories represent 36 possible combinations of wind direction, wind speed and atmospheric stability class conditions.

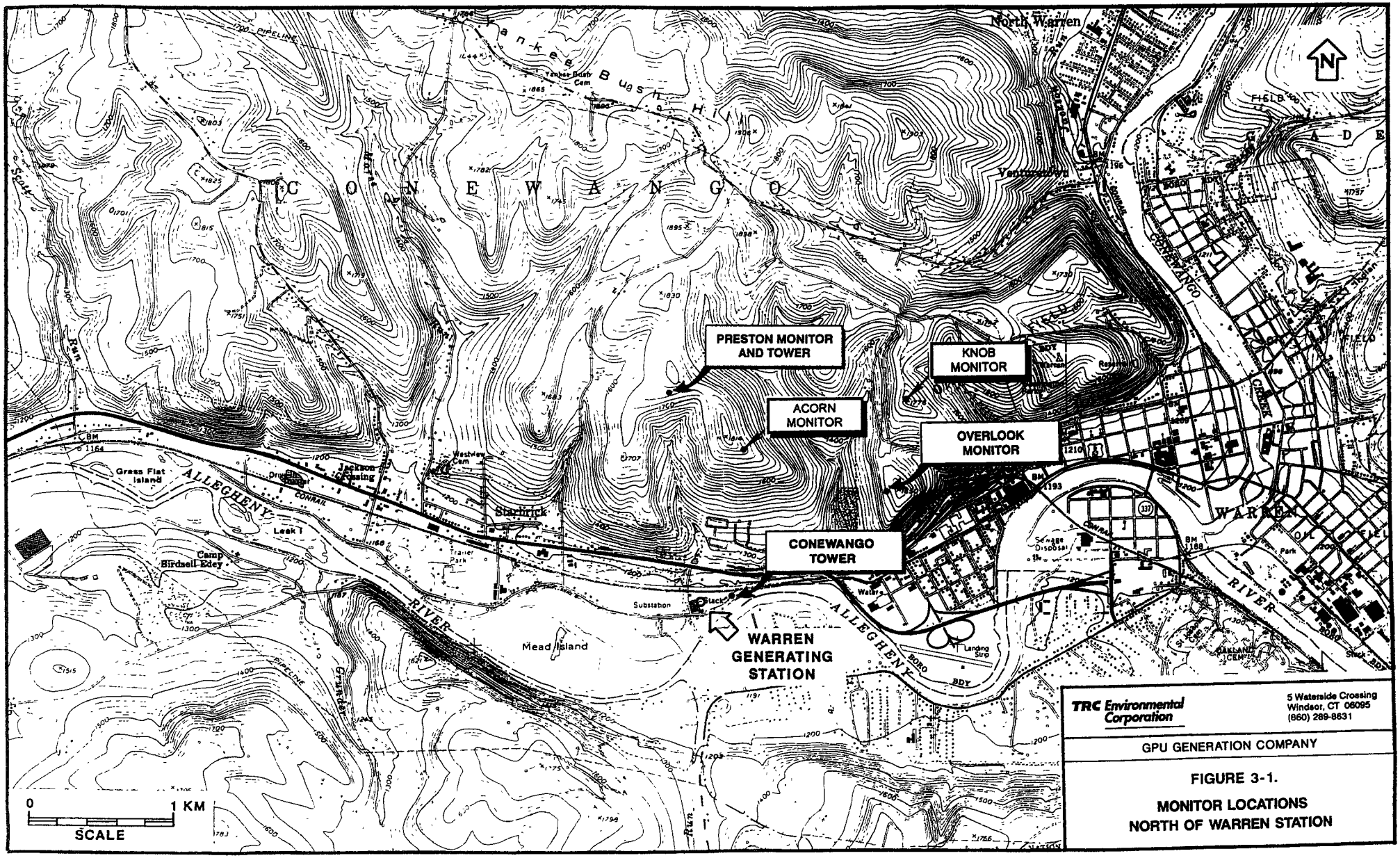


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FIGURE 3-1.

MONITOR LOCATIONS NORTH OF WARREN STATION

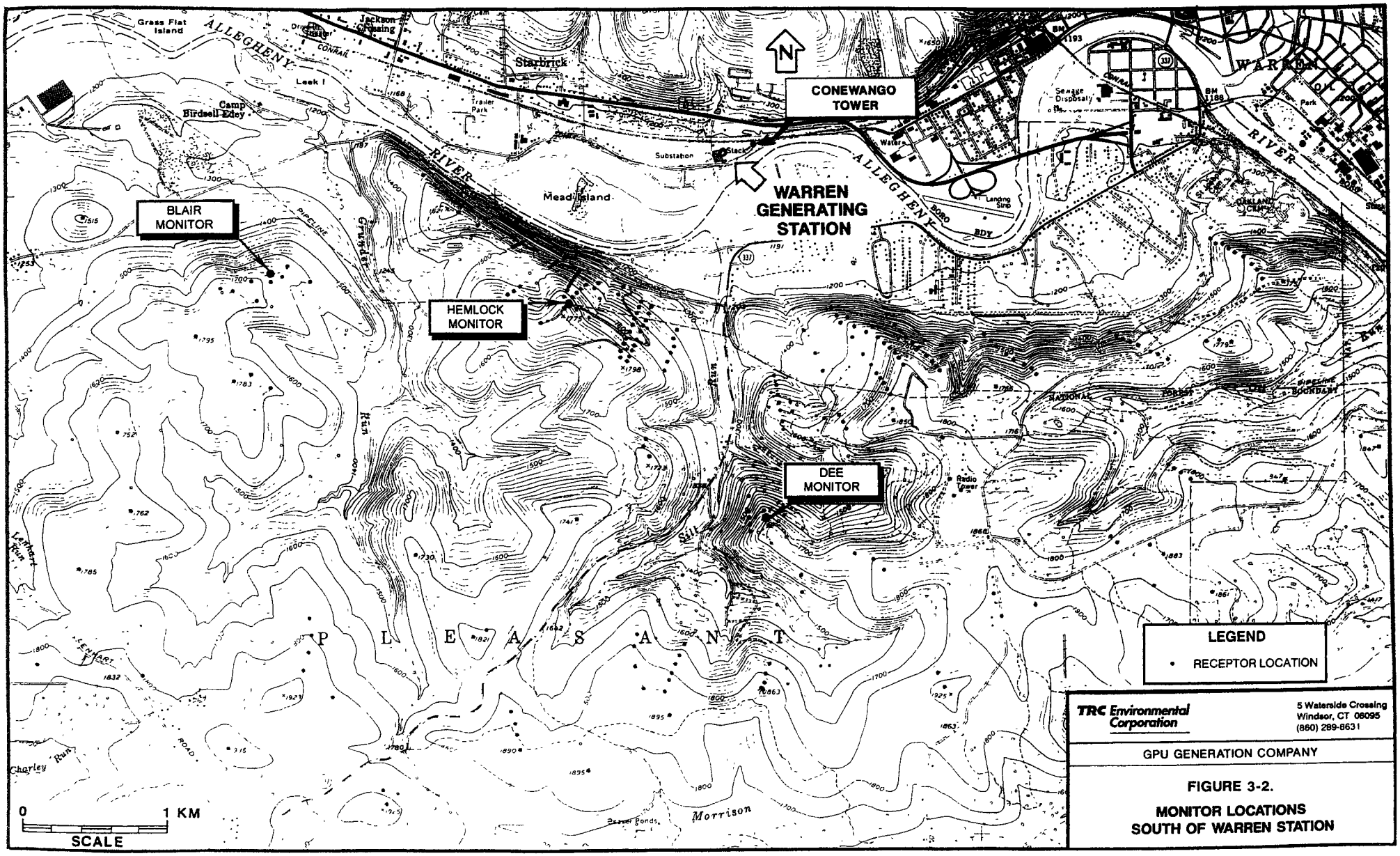

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FIGURE 3-2.

MONITOR LOCATIONS SOUTH OF WARREN STATION

Table 3–1
Categories of Meteorological Conditions Used for
Determining Background SO_2 Concentrations
for Warren Station and United Refining

Wind Direction Quadrant (degrees)	Atmospheric Stability Conditions	Wind Speed (m/s)
1–90	Stable (E, F)	0–3
90.1–180	Neutral (D)	3.01–5
180.1–270	Unstable (A, B, C)	>5.01
271.1–360		

Wind direction was separated into four 90 degree quadrants, wind speed into low, medium and high categories, and atmospheric stability into stable, unstable and neutral categories.

Representative hourly concentrations were determined for each meteorological data category based on the measurements at all upwind monitors (relative to the two plants) within each category. Figures 3-3, 3-4 and 3-5 show frequency distributions of the meteorological data by category for wind direction, wind speed and atmospheric stability, respectively. TRC determined that there were sufficient data in each category to determine a representative background concentration for each category.

The wind direction and speed data collected at the 150 meter level on the Conewango tower were used to determine the meteorological categories for those parameters, while the atmospheric stability class was determined using the 10 meter level sigma theta data at the Preston tower. The 150 meter tower level records wind data closest to the plume height of Warren Station and all of the largest emitting sources at United Refining. Whenever the desired data were missing, the alternative data (Table 3-2) specified in the model performance evaluation study were used instead. The SO_2 data measured during the 343 hours of upset conditions at United Refining (Table 3-3), as determined by DEP, were not included in the determination of the background concentrations.

The meteorological data were examined on an hour-by-hour basis to determine which of the seven monitors were impacted by either Warren Station or United Refining. For each hour, a monitor was considered to have been impacted by a given facility if it lay anywhere within a 90 degree sector downwind of the facility. This was done for each of the sources and monitors. If a monitor was determined to have been impacted by either facility, its concentration for that hour was not used in the background calculations. Under certain wind directions, all monitors were determined to have

Figure 3-3

Wind Direction Frequency Distribution

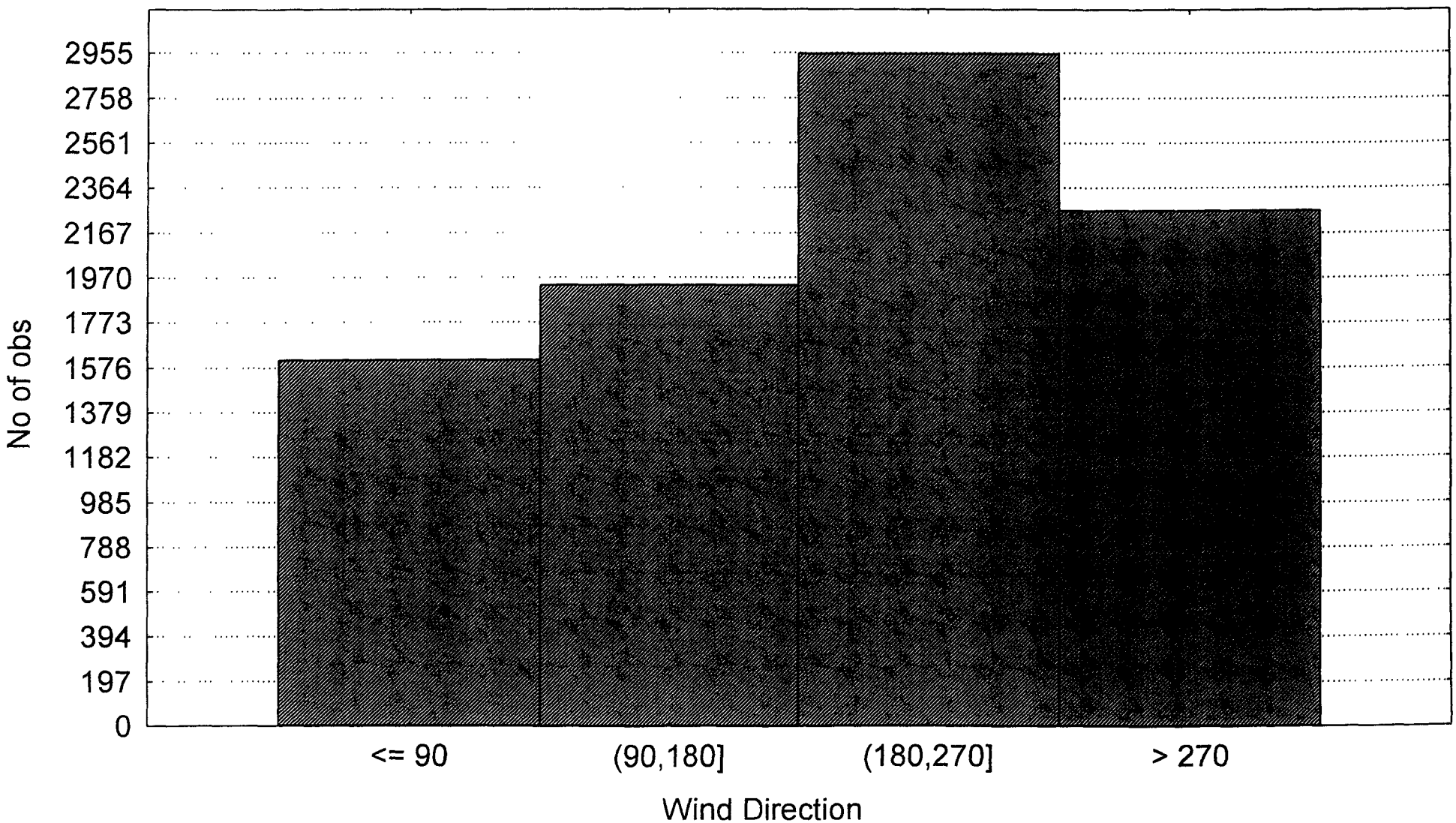

Figure 3-4

Wind Speed Frequency Distribution

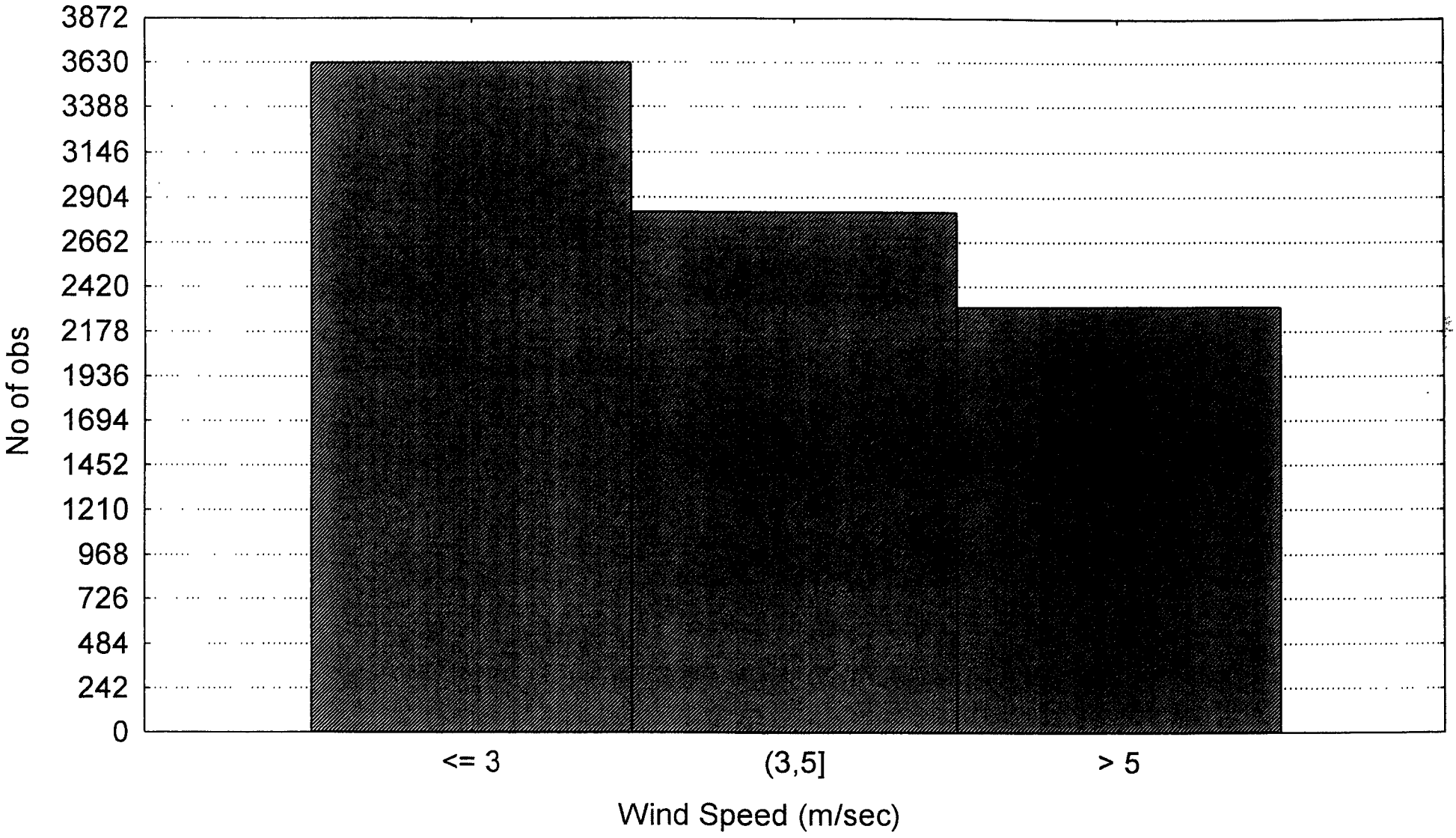

Figure 3-5

Atmospheric Stability Frequency Distribution

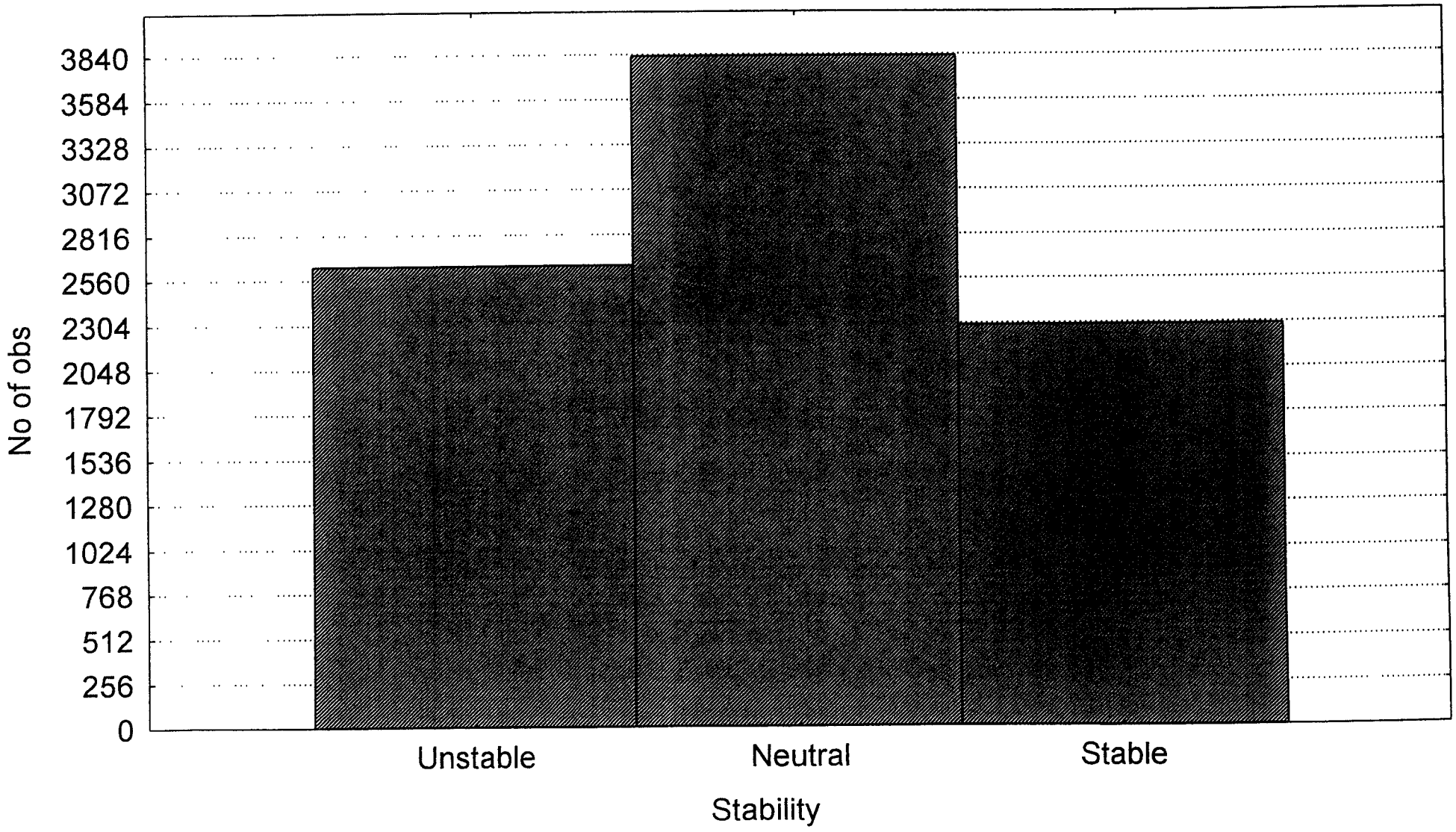

Table 3–2
Sources of Meteorological Data and Substitution Hierarchy Used for
Determining Background SO_2 Concentrations
for Warren Station and United Refining

Parameter	Sensor Level/ Source	Number of Hours Used
Wind Direction	C–150	8635
	C–125	33
	C–59	1
	Jamestown/Bradford NWS	91
Stack Top Wind Speed	C–59	8596
	C–125	71
	C–150	2
		91
Plume Height Wind Speed	C–150	8630
	C–125	33
	C–59	6
	Jamestown/Bradford NWS	91
Atmospheric Stability	P–10	7984
	Jamestown/Bradford NWS	776
Temperature	P–10	8552
	Jamestown/Bradford NWS	208

C–150 = Conewango 150 m level
C–125 = Conewango 125 m level
C–59 = Conewango 59 m level
P–10 = Preston 10 m level
NWS = National Weather Service

Table 3–3
Upset Events Identified by the Pennsylvania DEP

Year	Month	Day	Ending Hour	Year	Month	Day	Ending Hour
93	3	3	4	93	4	6	6
93	3	3	5	93	4	6	9
93	3	3	7	93	4	7	3
93	3	3	8	93	4	7	4
93	3	3	9	93	4	7	5
93	3	3	10	93	4	7	6
93	3	3	11	93	4	7	7
93	3	7	5	93	4	7	23
93	3	7	9	93	4	7	24
93	3	12	10	93	4	8	1
93	3	13	11	93	4	8	2
93	3	15	8	93	4	8	4
93	3	25	17	93	4	8	8
93	3	26	15	93	4	14	4
93	3	26	22	93	4	14	5
93	3	26	23	93	4	14	6
93	3	27	1	93	4	14	9
93	3	27	10	93	4	14	10
93	3	27	11	93	4	24	2
93	3	27	12	93	4	24	3
93	3	27	22	93	4	28	4
93	3	27	23	93	4	28	5
93	3	28	1	93	4	28	6
93	3	28	6	93	4	28	7
93	3	29	13	93	4	28	8
93	3	29	14	93	4	28	9
93	3	30	8	93	4	28	10
93	3	30	9	93	4	29	1
93	3	30	11	93	4	29	2
				93	4	29	3
				93	4	29	4
				93	4	29	5
				93	4	29	6
				93	4	29	7
				93	4	29	8
				93	4	29	9
				93	4	29	10

Table 3-3
Upset Events Identified by the Pennsylvania DEP

Year	Month	Day	Ending Hour	Year	Month	Day	Ending Hour
93	5	1	2	93	6	2	3
93	5	1	3	93	6	2	9
93	5	1	4	93	6	4	8
93	5	1	5	93	6	4	23
93	5	1	6	93	6	4	24
93	5	1	9	93	6	7	3
93	5	2	7	93	6	7	4
93	5	8	7	93	6	7	5
93	5	8	9	93	6	12	6
93	5	9	4	93	6	12	7
93	5	9	5	93	6	13	6
93	5	9	6	93	6	13	8
93	5	10	4	93	6	14	4
93	5	10	9	93	6	14	22
93	5	10	10	93	6	17	5
93	5	10	11	93	6	17	10
93	5	10	12	93	6	17	24
93	5	10	13	93	6	18	3
93	5	10	14	93	6	18	4
93	5	11	4	93	6	18	5
93	5	11	6	93	6	18	6
93	5	12	7	93	6	18	7
93	5	17	9	93	6	18	8
93	5	18	16	93	6	18	9
93	5	21	4	93	6	24	1
93	5	21	7	93	6	25	7
93	5	22	5				
93	5	23	7				
93	5	28	4				
93	5	28	5				
93	5	30	5				
93	5	30	6				

Table 3–3
Upset Events Identified by the Pennsylvania DEP

Year	Month	Day	Ending Hour	Year	Month	Day	Ending Hour
93	7	4	10	93	8	1	7
93	7	4	24	93	8	2	23
93	7	5	4	93	8	9	8
93	7	5	11	93	8	10	1
93	7	5	12	93	8	10	2
93	7	9	6	93	8	12	10
93	7	9	8	93	8	14	7
93	7	14	6	93	8	14	8
93	7	14	8	93	8	15	2
93	7	14	9	93	8	15	4
93	7	18	4	93	8	15	7
93	7	18	5	93	8	20	3
93	7	19	9	93	8	23	3
93	7	23	8	93	8	23	6
93	7	24	4	93	8	23	7
93	7	24	5	93	8	23	10
93	7	24	6	93	8	23	11
93	7	24	9	93	8	25	1
93	7	24	10	93	8	25	24
93	7	24	24	93	8	26	1
93	7	25	1	93	8	26	7
93	7	25	2	93	8	27	2
93	7	25	3	93	8	27	3
93	7	25	5	93	8	27	4
93	7	28	7	93	8	29	10
				93	8	30	11
				93	8	31	3

Table 3-3
Upset Events Identified by the Pennsylvania DEP

Year	Month	Day	Ending Hour	Year	Month	Day	Ending Hour
93	9	5	3	93	10	11	5
93	9	6	7	93	10	13	10
93	9	8	10	93	10	23	9
93	9	8	12	93	10	25	4
93	9	16	9	93	10	25	5
93	9	24	10	93	10	25	6
93	10	6	1	93	10	25	7
93	10	6	6	93	10	25	8
93	10	6	7	93	10	25	9
93	10	6	8	93	10	25	10
93	10	6	9	93	10	25	11
93	10	6	10	93	10	25	12
93	10	6	11	93	10	25	13
93	10	6	12	93	10	25	14
93	10	6	24	93	10	25	21
93	10	7	4	93	10	25	22
93	10	7	5	93	10	25	23
93	10	7	6	93	10	25	24
93	10	7	7	93	10	26	1
93	10	7	8	93	10	26	2
93	10	7	22	93	10	26	3
93	10	7	23	93	10	26	4
93	10	7	24	93	10	26	5
93	10	8	1	93	10	26	9
93	10	8	2	93	10	26	10
93	10	8	3				
93	10	8	4				
93	10	8	5				
93	10	8	6				
93	10	8	7				
93	10	8	8				
93	10	8	9				
93	10	8	10				
93	10	8	11				
93	10	8	12				
93	10	8	24				

Table 3-3
Upset Events Identified by the Pennsylvania DEP

Year	Month	Day	Ending Hour	Year	Month	Day	Ending Hour
93	11	9	24	93	12	9	20
93	11	10	1	93	12	9	22
93	11	10	2	93	12	13	1
93	11	10	3	93	12	13	6
93	11	10	4	93	12	13	7
93	11	10	5	93	12	13	9
93	11	10	6	93	12	13	19
93	11	10	8	93	12	13	20
93	11	10	9	93	12	13	22
93	11	22	23	93	12	13	23
93	11	22	24	93	12	13	24
93	11	23	1	93	12	14	1
93	11	23	11	93	12	14	2
93	11	23	12	93	12	14	3
93	11	23	13	93	12	14	4
93	11	23	14	93	12	14	6
93	11	23	15	93	12	14	9
93	11	23	16	93	12	14	10
93	11	23	17	93	12	14	12
93	11	23	22	93	12	14	15
93	11	23	23	93	12	14	19
93	11	23	24	93	12	14	21
93	11	24	1	93	12	14	22
93	11	24	2	93	12	15	21
93	11	24	3	93	12	24	4
93	11	24	4	93	12	27	6
93	11	24	5	93	12	27	7
93	11	24	6	93	12	27	8
93	11	24	7	93	12	27	9
93	11	24	8	93	12	27	10
93	11	24	9	93	12	28	21
93	11	24	12	93	12	29	1
				93	12	29	6
				93	12	29	12
				93	12	29	14

Table 3–3
Upset Events Identified by the Pennsylvania DEP

Year	Month	Day	Ending Hour	Year	Month	Day	Ending Hour
94	1	10	9	94	2	2	20
94	1	11	4	94	2	2	21
94	1	11	5	94	2	4	24
94	1	11	6	94	2	5	1
94	1	20	8	94	2	14	23
94	1	20	9	94	2	14	24
94	1	20	10	94	2	15	1
94	1	20	11	94	2	17	1
94	1	25	19	94	2	17	24
94	1	25	20	94	2	18	1
94	1	25	21	94	2	18	2
94	1	31	10	94	2	18	3
94	1	31	11	94	2	18	4
94	1	31	12	94	2	18	5
				94	2	18	6
				94	2	18	7
				94	2	18	8
				94	2	18	9
				94	2	18	10
				94	2	18	11
				94	2	18	12
				94	2	18	13
				94	2	18	14
				94	2	18	23
				94	2	18	24

been impacted by at least one of the two sources. For each of these conditions, the minimum reported concentration for all of the monitors was used for that hour.

The concentrations accumulated in the above process for each meteorological data category were then tabulated and the median concentration for all hours in each category was determined. The resulting background concentrations for the 36 categories are shown in Table 3-4. Each hour in the year was assigned an hourly background concentration based on the median value determined for the meteorological category applicable to that hour.

01-May-96

Table 3-4
Determination of the Background SO2 Concentrations
As a Function of the Meteorological Conditions

Bin Number	Wind Direction Quadrant	Stability	Wind Speed (m/sec)	Median Event Ave (µg/m^3)	Number of Monitor Hours Used	Number of Minimums Used	Number of Hours in Bin	Number of Eliminated Hours
1	Southwest	Stable	LT 3	14.4	1320	0	325	7
2	Southwest	Stable	3-5	19.7	1002	0	263	2
3	Southwest	Stable	GT 5	20.3	270	0	65	0
4	Southwest	Neutral	LT 3	12.1	597	0	139	2
5	Southwest	Neutral	3-5	15.7	1619	0	375	2
6	Southwest	Neutral	GT 5	13.1	2900	0	622	0
7	Southwest	Unstable	LT 3	13.6	983	0	243	7
8	Southwest	Unstable	3-5	15.7	2121	0	509	2
9	Southwest	Unstable	GT 5	14.5	1769	0	410	0
10	Northwest	Stable	LT 3	9.7	1995	0	323	3
11	Northwest	Stable	3-5	6.3	490	0	77	0
12	Northwest	Stable	GT 5	6.3	85	0	14	0
13	Northwest	Neutral	LT 3	10.1	1417	0	232	1
14	Northwest	Neutral	3-5	7.9	2619	0	422	0
15	Northwest	Neutral	GT 5	7.7	3416	0	556	0
16	Northwest	Unstable	LT 3	10.9	1418	0	239	10
17	Northwest	Unstable	3-5	6.6	1593	0	263	0
18	Northwest	Unstable	GT 5	5.7	855	0	138	0
19	Northeast	Stable	LT 3	11.4	1317	222	679	119
20	Northeast	Stable	3-5	5.9	266	11	83	3
21	Northeast	Stable	GT 5	7.5	112	1	34	2
22	Northeast	Neutral	LT 3	10.5	536	92	250	43
23	Northeast	Neutral	3-5	6.3	394	31	114	3
24	Northeast	Neutral	GT 5	5.2	129	12	40	1
25	Northeast	Unstable	LT 3	10.5	710	73	277	32
26	Northeast	Unstable	3-5	6.8	341	19	112	5
27	Northeast	Unstable	GT 5	6.6	42	5	19	1
28	Southeast	Stable	LT 3	10.5	619	168	363	42
29	Southeast	Stable	3-5	12.4	138	13	55	3
30	Southeast	Stable	GT 5	13.1	27	2	12	1
31	Southeast	Neutral	LT 3	13.1	619	137	330	27
32	Southeast	Neutral	3-5	14.8	891	165	424	10
33	Southeast	Neutral	GT 5	11.8	832	66	327	0
34	Southeast	Unstable	LT 3	10.5	465	91	227	14
35	Southeast	Unstable	3-5	13.1	303	54	128	1
36	Southeast	Unstable	GT 5	16.2	217	9	71	0

Median	Sum	Sum	Sum	Sum
10.7	34427	1171	8760	343

4.0 TRC MODELING RESULTS

Separate modeling analyses were performed for two operating scenarios at Warren Station. The first set of analyses was performed for both generating units operating simultaneously and the second was performed for either unit operating alone. The receptors with any predicted violations are depicted with filled circles in Figures 2-1 and 2-2.

4.1 Operation of Two Generating Units at Warren Station

4.1.1 3-hour Average NAAQS

The TRC modeling analyses produced no predicted 3-hour average NAAQS violations (i.e., no second high values that exceeded the NAAQS at any receptor) on the Washington Park hills (see Table 4-1).

The 3-hour average NAAQS violations predicted by the TRC modeling analyses all occurred on the St Joseph/Oakland cemeteries hills. A total of sixteen (16) violations was predicted at a total of five receptors (numbered 169, 170, 172, 173 and 174). Thirteen (13) of the predicted violations of the 3-hour average NAAQS were due to United Refining alone, the other three were primarily due to United Refining but included significant contributions from Warren Station.

4.1.2 24-hour Average NAAQS

The TRC modeling analyses produced eight (8) predicted 24-hour average NAAQS violations on the Washington Park hills (see Table 4-2). Six (6) of the predicted violations (which occurred at receptor numbers 147, 149 and 151) were entirely attributable to Warren Station while the remaining two (2) included small impacts from United Refining.

5/1/96

Table 4-1
3-Hour Average SO_2 Concentrations that Exceed the NAAQS when Both Warren Station Units Are in Operation at 4.0 lbs/MMBtu

Receptor Number	Julian Day	Ending Hour	SO_2 Concentrations ($\mu g/m^3$)					Percent Over
			Warren	United	Combined	Background	Total	
133	109	6	1355	0	1355	19.7	1375	5.78
135	109	6	1311	0	1311	19.7	1331	2.40
136	109	6	1287	0	1287	19.7	1307	0.51
149	326	3	1324	0	1324	19.9	1344	3.37
151	326	3	1299	0	1299	19.9	1319	1.43
169	85	6	0	1401	1401	10.8	1412	8.58
169	279	6	0	1383	1383	10.8	1393	7.19
170	85	6	0	1535	1535	10.8	1546	18.9
170	230	6	83.1	1314	1397	10.8	1408	8.32
170	351	6	0	1329	1329	11.4	1341	3.14
171	85	6	0	1383	1383	10.8	1394	7.23
172	230	6	100	1369	1469	10.8	1480	13.9
172	192	3	323	1064	1387	10.5	1398	7.52
172	281	6	0	1383	1383	11.4	1395	7.30
172	351	6	0	1366	1366	11.4	1378	5.99
172	85	6	0	1336	1336	10.8	1346	3.57
173	230	6	106	1399	1505	10.8	1516	16.6
173	192	3	349	1086	1435	10.5	1445	11.2
173	281	6	0	1421	1421	11.4	1432	10.2
173	351	6	0	1408	1408	11.4	1420	9.22
173	85	6	0	1358	1358	10.8	1369	5.30
173	268	3	0	1339	1339	11.4	1351	3.89
173	251	6	0	1300	1300	11.4	1311	0.88
174	268	3	0	1469	1469	11.4	1481	13.9
174	190	6	0	1335	1335	11.4	1347	3.60
174	131	6	0	1295	1295	11.4	1306	0.49
174	12	6	0	1295	1295	11.1	1306	0.48
176	251	6	0	1328	1328	11.4	1340	3.07
177	251	6	0	1348	1348	11.4	1360	4.59

Second High for that Receptor

Table 4-2
24-Hour Average SO_2 Concentrations that Exceed the NAAQS when Both Warren Station Units Are In Operation at 4.0 lbs/MMBtu

Receptor Number	Julian Day	Ending Hour	SO_2 Concentrations ($\mu g/m^3$)					Percent Over
			Warren	United	Combined	Background	Total	
147	326	24	484	0	484	15.8	500	37.0
147	19	24	364	0	364	15.3	379	3.96
148	326	24	530	0	530	15.8	545	49.4
149	326	24	562	0	562	15.8	577	58.2
149	19	24	396	0	396	15.3	411	12.6
149	352	24	385	6.11	391	13.7	405	10.8
149	315	24	357	0	357	16.2	373	2.23
150	326	24	526	0	526	15.8	542	48.5
151	326	24	531	0	531	15.8	547	49.9
151	352	24	390	5.79	396	13.7	410	12.3
151	19	24	378	0	378	15.3	393	7.71
151	315	24	356	0	356	16.2	373	2.11
151	32	24	357	0	357	14.4	372	1.80
152	326	24	411	0	411	15.8	427	17.1
153	326	24	392	0	392	15.8	408	11.7
154	326	24	353	11.8	365	15.8	381	4.41
158	297	24	389	0.189	389	15.7	405	11.0
159	297	24	352	0.346	352	15.7	368	0.74
169	85	24	0	504	504	10.6	515	41.1
170	85	24	0	554	554	10.6	565	54.7
170	281	24	1.43	390	392	12.3	404	10.7
170	351	24	51.1	302	353	12.5	366	0.25
171	85	24	0	455	455	10.6	465	27.4
172	85	24	0	550	550	10.6	561	53.6
172	86	24	0	378	378	10.3	389	6.46
173	85	24	0	571	571	10.6	581	59.3
173	227	24	24.8	368	393	10.4	403	10.5
173	86	24	0	387	387	10.3	398	8.93
173	351	24	51.4	306	357	12.5	370	1.24
174	85	24	0	414	414	10.6	425	16.4
174	227	24	24.3	384	409	10.4	419	14.8
174	238	24	11.3	347	358	11.2	370	1.25
176	347	24	0.652	360	361	10.9	372	1.91
328	250	24	349	26.0	375	10.4	385	5.47
354	26	24	349	13.6	363	7.31	370	1.33
381	241	24	335	45.0	380	9.55	390	6.79
381	347	24	362	14.8	377	10.9	388	6.20
387	347	24	382	14.4	397	10.9	407	11.6
387	241	24	338	43.6	381	9.55	391	7.06
388	347	24	337	27.9	365	10.9	375	2.86
391	347	24	376	8.41	384	10.9	395	8.29
401	85	24	283	76.8	360	10.6	370	1.49
401	238	24	325	28.8	354	11.2	365	0.10
402	85	24	297	74.3	372	10.6	382	4.71
402	238	24	343	27.9	371	11.2	382	4.68
403	85	24	300	75.0	375	10.6	386	5.64
403	238	24	345	28.1	373	11.2	384	5.25
412	26	24	349	13.6	363	7.31	370	1.33

Second High for that Receptor

The TRC modeling analyses also produced eight (8) predicted 24-hour average NAAQS violations on the St. Joseph/Oakland cemeteries hills. Of those predicted violations (which occurred at receptor numbers 170, 172, 173 and 174), two (2) were entirely attributable to United Refining and the remaining six (6) included small impacts (one of which is below the concentration defined as significant) from Warren Station.

The TRC modeling analyses also produced five (5) predicted violations of the 24-hour average SO_2 NAAQS on other hills (receptor numbers 381, 387, 401, 402 and 403) that are located west southwest of both Warren Station and United Refining. Warren Station was responsible for 86 to 93 percent of the predicted total concentrations at those receptors.

4.1.3 Annual Average NAAQS

The TRC modeling analyses produced no predicted annual average NAAQS violations (i.e., no high values that exceeded the NAAQS at any receptor) on the Washington Park hills (see Table 4-3).

The TRC modeling analyses produced four (4) predicted annual average NAAQS violations on the St. Joseph/Oakland cemeteries hills (at receptor numbers 170, 172, 173 and 174). The contributions to the total predicted concentrations were roughly 31, 56 and 13 percent from Warren Station, United Refining and background, respectively.

Table 4-3
Annual Average SO_2 Concentrations that Exceed the NAAQS when Both Warren Station Units Are in Operation at 4.0 lbs/MMBtu

Receptor Number	Julian Day	Ending Hour	SO_2 Concentrations ($\mu g/m^3$)					Percent Over
			Warren	United	Combined	Background	Total	
174	N/A	N/A	28.8	54.8	83.6	11.8	95.4	19.2
173	N/A	N/A	29.1	52.1	81.2	11.8	92.9	16.2
172	N/A	N/A	27.6	49.9	77.5	11.8	89.3	11.6
170	N/A	N/A	26.7	46.1	72.8	11.8	84.6	5.75

4.2 Operation of One Generating Unit at Warren Station

4.2.1 3-hour Average NAAQS

The TRC modeling analyses produced no predicted 3-hour average NAAQS violations (i.e., no second high values that exceeded the NAAQS at any receptor) on the Washington Park hills (see Table 4-4).

The 3-hour average NAAQS violations predicted by the TRC modeling analyses all occurred on the St. Joseph/Oakland cemeteries hills. A total of sixteen (16) violations was predicted at a total of five receptors (numbered 169, 170, 172, 173 and 174). Thirteen (13) of the predicted violations of the 3-hour average NAAQS were due to United Refining alone, the other three were primarily due to United Refining but included significant contributions from Warren Station.

4.2.2 24-hour Average NAAQS

The TRC modeling analyses produced no predicted 24-hour average NAAQS violations (i.e., no second high values that exceeded the NAAQS at any receptor) on the Washington Park hills (see Table 4-5).

The TRC modeling analyses produced six (6) predicted 24-hour average NAAQS violations on the St. Joseph/Oakland cemeteries hills. Of those predicted violations (which occurred at receptor numbers 170, 172, 173 and 174), two (2) were entirely attributable to United Refining and the remaining four (4) included small impacts (one of which is below the concentration defined as significant) from Warren Station.

The TRC modeling analyses produced no predicted violations of the 24-hour average SO_2 NAAQS on any other hills.

Table 4-4
3-Hour Average SO_2 Concentrations that Exceed the NAAQS when Only Warren Station Unit One or Two Is in Operation at 4.0 lbs/MMBtu

Receptor Number	Julian Day	Ending Hour	SO_2 Concentrations ($\mu g/m^3$)					Percent Over
			Warren	United	Combined	Background	Total	
169	85	6	0	1401	1401	10.8	1412	8.58
169	279	6	0	1383	1383	10.8	1393	7.19
170	85	6	0	1535	1535	10.8	1546	18.9
170	230	6	41.9	1314	1356	10.8	1367	5.15
170	351	6	0	1329	1329	11.4	1341	3.13
171	85	6	0	1383	1383	10.8	1394	7.23
172	230	6	53.7	1369	1423	10.8	1434	10.3
172	281	6	0	1383	1383	11.4	1395	7.29
172	351	6	0	1366	1366	11.4	1378	5.99
172	192	3	272	1064	1336	10.5	1347	3.61
172	85	6	0	1336	1336	10.8	1346	3.57
173	230	6	56.7	1399	1456	10.8	1467	12.8
173	281	6	0	1421	1421	11.4	1432	10.2
173	351	6	0	1408	1408	11.4	1420	9.21
173	192	3	293	1086	1380	10.5	1390	6.94
173	85	6	0	1358	1358	10.8	1369	5.30
173	268	3	0	1339	1339	11.4	1350	3.88
173	251	6	0	1300	1300	11.4	1311	0.87
174	268	3	0	1469	1469	11.4	1481	13.9
174	190	6	0	1335	1335	11.4	1347	3.60
174	131	6	0	1295	1295	11.4	1306	0.48
174	12	6	0	1295	1295	11.1	1306	0.48
176	251	6	0	1328	1328	11.4	1340	3.07
177	251	6	0	1348	1348	11.4	1360	4.59

Second High for that Receptor

5/7/96

Table 4-5
24-Hour Average SO_2 Concentrations that Exceed the NAAQS when Only Warren Station Unit One or Two Is in Operation at 4.0 lbs/MMBtu

Receptor Number	Julian Day	Ending Hour	SO_2 Concentrations ($\mu g/m^3$)					Percent Over
			Warren	United	Combined	Background	Total	
148	326	24	352	0	352	15.8	367	2.08
149	326	24	383	0	383	15.8	399	10.8
150	326	24	380	0	380	15.8	396	10.0
151	326	24	358	0	358	15.8	374	3.93
169	85	24	0	504	504	10.6	515	43.0
170	85	24	0	554	554	10.6	565	56.9
170	281	24	0.737	390	391	12.3	403	12.0
171	85	24	0	455	455	10.6	465	29.2
172	85	24	0	550	550	10.6	561	55.7
172	86	24	0	378	378	10.3	389	7.94
173	85	24	0	571	571	10.6	581	61.5
173	86	24	0	387	387	10.3	398	10.4
173	227	24	15.1	368	383	10.4	393	9.28
174	85	24	0	414	414	10.6	425	18.0
174	227	24	14.7	384	399	10.4	409	13.7
174	238	24	7.39	347	354	11.2	366	1.56
176	347	24	0.053	360	360	10.9	371	3.16

Second High for that Receptor

4.2.3 Annual Average NAAQS

The TRC modeling analyses produced no predicted annual average NAAQS violations (i.e., no high values that exceeded the NAAQS at any receptor) on the Washington Park hills (see Table 4-6).

The TRC modeling analyses produced three (3) predicted annual average NAAQS violations on the St. Joseph/Oakland cemeteries hills (at receptor numbers 172, 173 and 174). The contributions to the total predicted concentrations were roughly 25, 61 and 14 percent from Warren Station, United Refining and background, respectively.

Table 4-6
Annual Average SO_2 Concentrations that Exceed the NAAQS when Only Warren Station Unit One or Two Is in Operation at 4.0 lbs/MMBtu

Receptor Number	Julian Day	Ending Hour	SO_2 Concentrations ($\mu g/m^3$)					Percent Over
			Warren	United	Combined	Background	Total	
174	N/A	N/A	21.6	54.8	76.4	11.8	88.2	10.2
173	N/A	N/A	22.1	52.1	74.2	11.8	86.0	7.51
172	N/A	N/A	21.2	49.9	71.1	11.8	82.9	3.57

5.0 DEMONSTRATION OF NAAQS COMPLIANCE

Table 5-1 shows the identification of the CTSCREEN receptors that most closely correspond to the five LAPPES receptors where LAPPES/RTDM produced the predicted violations of the 3-hour average NAAQS. Table 5-2 shows the Warren Station (LAPPES) and United Refining (RTDM) source contributions to those predicted NAAQS violations. Table 5-3 shows the maximum 1-hour, 3-hour, 24-hour and annual average impacts predicted by CTSCREEN for the United Refining sources at the five receptors shown in Table 5-1.

Table 5-4 shows that no 3-hour average NAAQS violations are predicted when the maximum hourly impacts produced by CTSCREEN are substituted for those produced by RTDM. Table 5-4a shows that result for the case when both Warren Station units are operating simultaneously and Table 5-4b shows that result for the case when either unit one or unit two operates alone.

Therefore, in order to meet the 3-hour average NAAQS on CTSCREEN hill No. 1, *no* emission rate reductions are required at *either* Warren Station or United Refining (i.e., compliance is achieved with Warren Station operating at an emission rate limit of 4.00 lbs/MMBtu).

Table 5-5 shows the results of the hybrid modeling procedure for the 24-hour averaging period. Tables 5-5a and 5-5b show the results for the cases where 1) both Warren Station units are operating simultaneously and 2) either unit operates alone, respectively. Table 5-5a shows that compliance with the 24-hour average NAAQS will be achieved if the SO_2 emission rate is limited to 3.53 lbs/MMBtu when both units are in operation at Warren Station. Table 5-5b shows compliance with the 24-hour average NAAQS when either Warren Station unit operates alone with an SO_2 emission rate limit of 4.00 lbs/MMBtu.

Table 5–1
Comparison of the Locations of the Maximum CTSCREEN Impacts
on Hill No. 1 to the Locations of
LAPPES Receptors 169, 170, 172, 173 and 174

Receptor Location Comparisons

Coordinate Type	Units	UTM Coordinates (A) CTSCREEN Grid Origin	(B) LAPPES Receptor	(C) CTSCREEN Maximum	Distance Difference (B)–(C)	DEP Coordinates CTSCREEN Maximum (No. 339) [a]	(B)–(A) LAPPES Receptor	Closest CTSCREEN Receptor [b]
LAPPES Receptor No. 169								
x	km	655.660	654.110	654.669	−0.559	−0.991	−1.550	−1.561
y	km	4632.170	4632.220	4632.224	−0.004	0.054	0.050	0.057
z	ft		1,600	1,660		1,660	1,600	1,580
LAPPES Receptor No. 170								
x	km	655.660	654.180	654.669	−0.489	−0.991	−1.480	−1.471
y	km	4632.170	4632.210	4632.224	−0.014	0.054	0.040	0.055
z	ft		1,640	1,660		1,660	1,640	1,660
LAPPES Receptor No. 172								
x	km	655.660	654.210	654.669	−0.459	−0.991	−1.450	−1.463
y	km	4632.170	4632.130	4632.224	−0.094	0.054	−0.040	−0.100
z	ft		1,680	1,660		1,660	1,680	1,700
LAPPES Receptor No. 173								
x	km	655.660	654.260	654.669	−0.409	−0.991	−1.400	−1.401
y	km	4632.170	4632.120	4632.224	−0.104	0.054	−0.050	−0.029
z	ft		1,720	1,660		1,660	1,720	1,700
LAPPES Receptor No. 174								
x	km	655.660	654.400	654.669	−0.269	−0.991	−1.260	−1.237
y	km	4632.170	4632.020	4632.224	−0.204	0.054	−0.150	−0.172
z	ft		1,751	1,660		1,660	1,751	1,700

Receptor Number Comparisons [b]

Model	Receptor Number					
LAPPES	None	169	170	172	173	174
CTSCREEN	339	267	334	363	364	369

[a] the maximum CTSCREEN impacts occur at CTSCREEN receptor No. 339 on Hill No. 1.
[b] the CTSCREEN receptor numbers are shown for the CTSCREEN receptors that are closest to the corresponding LAPPES receptor number.

Table 5-2
Source Contribution Analysis for the 3-hour Periods when Both
Warren Station (using LAPPES) and United Refining (using RTDM)
Contribute to Predicted Exceedances of the SO_2 NAAQS
(with Warren Station's SO_2 Emissions at 4.0 lbs/MMBtu)

			SO_2 Concentration ($\mu g/m^3$)			Meteorological Conditions		
Receptor Number	Julian Date	Ending Hour	Warren Station (LAPPES)	United Refining (RTDM)	Total	Wind Direction (Deg. Azi.)	Wind Speed (m/s)	Stability Class
172	192	1	970	0	970	281	1.00	6
		2	0	1201	1201	96	1.00	6
		3	0	1990	1990	80	1.00	6
	3-hour Average		323	1064	1387			
173	192	1	1046	0	1046	281	1.00	6
		2	0	1227	1227	96	1.00	6
		3	0	2032	2032	80	1.00	6
	3-hour Average		349	1086	1435			
170	230	4	249	0	249	299	1.12	6
		5	0	2152	2152	76	1.00	6
		6	0	1790	1790	84	1.00	6
	3-hour Average		83.1	1314	1397			
172	230	4	300	0	300	299	1.12	6
		5	0	2166	2166	76	1.00	6
		6	0	1946	1946	84	1.00	6
	3-hour Average		100	1371	1471			
173	230	4	318	0	318	299	1.12	6
		5	0	2212	2212	76	1.00	6
		6	0	1986	1986	84	1.00	6
	3-hour Average		106	1399	1505			

Table 5–3
Comparison of the Maximum CTSCREEN Impacts on Hill No. 1
to the CTSCREEN Impacts at the Locations of
LAPPES Receptors 169, 170, 172, 173 and 174

CTSCREEN Location	Receptor Number CTSCREEN	Receptor Number LAPPES	SO_2 Concentrations Predicted by CTSCREEN ($\mu g/m^3$) 1–hour	Difference from Max. [a]	3–hour	Difference from Max. [a]	24–hour	Difference from Max. [a]	Annual	Difference from Max. [a]
Stable Hours										
Maximum	339	N/A	1,310	N/A	917	N/A	197	N/A	39.3	N/A
	267	169	741	569	519	398	111	85.3	22.2	17.1
	334	170	1218	91.5	853	64.1	183	13.7	36.6	2.75
	363	172	1127	183	789	128	169	27.4	33.8	5.48
	364	173	1128	181	790	127	169	27.2	33.9	5.45
	369	174	1104	206	773	144	166	30.8	33.1	6.17
Unstable Hours										
Maximum	365	N/A	1202	N/A	842	N/A	180	N/A	36.1	N/A
	267	169	1064	138	745	96.6	160	20.7	31.9	4.14
	334	170	1118	84.7	782	59.3	168	12.7	33.5	2.54
	363	172	1098	105	768	73.3	165	15.7	32.9	3.14
	364	173	1172	30.6	820	21.4	176	4.59	35.1	0.918
	369	174	1109	93.1	776	65.2	166	14.0	33.3	2.79

[a] for the given stability classification

Table 5–4a
Recalculation of the Warren Station 3–hour SO_2 Emission Limit Based on the Hybrid Modeling Results for the Receptors with Predicted NAAQS Violations in Table 4–1.
(Both Warren Station Units Operating) [a]

LAPPES Receptor Number	Julian Date	Ending Hour	SO_2 Concentrations: Warren Station (LAPPES) [b]	United Refining (CTSCREEN)	Subtotal	Back–ground [c]	Total	Required Percent Reduction
170	230	4	249	0	249	9.7		
		5	0	1218	1218	11.4		
		6	0	1218	1218	11.4		
	3–hour Average		83.1	812	895	10.8	906	0.0
172	192	1	970	0	970	9.7		
		2	0	1127	1127	10.5		
		3	0	1127	1127	11.4		
	3–hour Average		323	751	1075	10.5	1085	0.0
172	230	4	300	0	300	9.7		
		5	0	1127	1127	11.4		
		6	0	1127	1127	11.4		
	3–hour Average		100	751	851	10.8	862	0.0
173	192	1	1046	0	1046	9.7		
		2	0	1128	1128	10.5		
		3	0	1128	1128	11.4		
	3–hour Average		349	752	1101	10.5	1111	0.0
173	230	4	318	0	318	9.7		
		5	0	1128	1128	11.4		
		6	0	1128	1128	11.4		
	3–hour Average [d]		106	752	858	10.8	869	0.0

[a] this table only shows the five 3–hour periods with predicted contributions from Warren Station. All the other predicted violations shown in Table 4–1 were due to United Refining alone using RTDM, and the CTSCREEN modeling results in Table 5–3 show no predicted NAAQS violations at the same receptors.
[b] at an SO_2 emission rate of 4.0 lbs/MMBtu.
[c] the hourly values are the median values for the meteorological data category shown in Table 5–2.
[d] new highest second high 3–hour average.

Table 5–4b
Recalculation of the Warren Station 3–hour SO_2 Emission Limit Based on the Hybrid Modeling Results for the Receptors with Predicted NAAQS Violations in Table 4–4 (Warren Station Unit One or Two Operating) [a]

LAPPES Receptor Number	Julian Date	Ending Hour	SO_2 Concentrations: Warren Station (LAPPES) [b]	United Refining (CTSCREEN)	Subtotal	Back–ground [c]	Total	Required Percent Reduction
170	230	4	126	0	126	9.7		
		5	0	1218	1218	11.4		
		6	0	1218	1218	11.4		
	3–hour Average		41.9	812	854	10.8	865	0.0
172	192	1	817	0	817	9.7		
		2	0	1127	1127	10.5		
		3	0	1127	1127	11.4		
	3–hour Average		272	751	1024	10.5	1034	0.0
172	230	4	161	0	161	9.7		
		5	0	1127	1127	11.4		
		6	0	1127	1127	11.4		
	3–hour Average		53.7	751	805	10.8	816	0.0
173	192	1	880	0	880	9.7		
		2	0	1128	1128	10.5		
		3	0	1128	1128	11.4		
	3–hour Average		293	752	1045	10.5	1056	0.0
173	230	4	170	0	170	9.7		
		5	0	1128	1128	11.4		
		6	0	1128	1128	11.4		
	3–hour Average [d]		56.7	752	809	10.8	819	0.0

[a] this table only shows the five 3–hour periods with predicted contributions from Warren Station. All the other predicted violations shown in Table 4–4 were due to United Refining alone using RTDM, and the CTSCREEN modeling results in Table 5–3 show no predicted NAAQS violations at the same receptors.
[b] at an SO_2 emission rate of 4.0 lbs/MMBtu.
[c] the hourly values are the median values for the meteorological data category shown in Table 5–2.
[d] new highest second high 3–hour average.

Table 5–5a
Recalculation of the Warren Station 24–hour SO_2 Emission Limit Based on the Hybrid Modeling Results for the Receptors with Predicted NAAQS Violations in Table 4–2 (Both Warren Station Units Operating) [a]

LAPPES Receptor Number	Julian Date	SO_2 Concentrations: Warren Station (LAPPES) [b]	United Refining (RTDM)	United Refining (CTSCREEN) [c]	Subtotal [d]	Back–ground	Total	Required Percent Reduction
147	19	321	0	N/A	321	15.3	337	0.0
149	19	349	0	N/A	349	15.3	365	0.0
149	352	340	6.11	N/A	346	13.7	359	0.0
149	315	315	0	N/A	315	16.2	331	0.0
151	352	344	5.79	N/A	350	13.7	364	0.0
151	19	333	0	N/A	333	15.3	349	0.0
151	315	315	0	N/A	315	16.2	331	0.0
151	32	315	0	N/A	315	14.4	330	0.0
170	281	1.26	390	183	184	12.3	197	0.0
170	351	45.1	302	183	228	12.5	241	0.0
172	86	0	378	169	169	10.3	179	0.0
173	227	21.9	368	176	198	10.4	208	0.0
173	86	0	387	176	176	10.3	186	0.0
173	351	45.4	306	176	221	12.5	234	0.0
174	227	21.5	384	166	187	10.4	198	0.0
174	238	10.0	347	166	176	11.2	187	0.0
381	347	319	14.8	N/A	334	10.9	345	0.0
387	241	298	43.6	N/A	342	9.55	351	0.0
401	238	287	28.8	N/A	316	11.2	327	0.0
402	238	303	27.9	N/A	331	11.2	342	0.0
403	238	304	28.1	N/A	332	11.2	344	0.0

[a] this table shows the 21 days of predicted NAAQS violations from Table 4–2 (i.e., the 21 days where the second through nth highest values exceeded the NAAQS at a given receptor).
[b] at an SO_2 emission rate of 3.53 lbs/MMBtu.
[c] see Table 5–3.
[d] LAPPES + RTDM for receptors 147–151 and 381–403, LAPPES + CTSCREEN for receptors 170–174.

N/A = not available

Table 5–5b
Recalculation of the Warren Station 24–hour SO_2 Emission Limit Based on the Hybrid Modeling Results for the Receptors with Predicted NAAQS Violations in Table 4–5 (Warren Station Unit One or Two Operating) [a]

LAPPES Receptor Number	Julian Date	SO_2 Concentrations: Warren Station (LAPPES) [b]	United Refining (RTDM)	United Refining (CTSCREEN) [c]	Subtotal [d]	Back–ground	Total	Required Percent Reduction
170	281	0.737	390	182.77	184	12.3	196	0.0
172	86	0	378	169.08	169	10.3	179	0.0
173	86	0	387	175.74	176	10.3	186	0.0
173	227	15.1	368	175.74	191	10.4	201	0.0
174	227	14.7	384	166.36	181	10.4	191	0.0
174	238	7.39	347	166.36	174	11.2	185	0.0

[a] this table shows the 6 days of predicted NAAQS violations from Table 4–5 (i.e., the 6 days where the second through nth highest values exceeded the NAAQS at a given receptor).
[b] at an SO_2 emission rate of 4.00 lbs/MMBtu.
[c] see Table 5–3.
[d] LAPPES + CTSCREEN.

Tables 5-6 (a and b) show the compliance analysis results for the annual averaging period. The tables show compliance with the annual average NAAQS for both Warren Station operating scenarios (i.e., both units or one unit operation) with an SO_2 emission rate limit of 4.00 lbs/MMBtu.

Table 5-7 shows the revised compliance analysis results for the three hills where only CTSCREEN was used to model the combined impacts of Warren Station and United Refining. The predicted SO_2 concentrations presented in Table 5-7 were obtained or derived from DEP's January 3, 1995 report (DEP, 1995). The model-predicted concentrations in Table 5-7 represent the combined impacts of both Warren Station and United Refining. However, the revised combined impacts of the two facilities were calculated based on the very conservative assumption that the model-predicted impacts were entirely attributable to Warren Station. Thus, the original total 3-hour average impacts of the two facilities were multiplied by 4.0/3.2 to obtain their revised total 3-hour average impacts, and the original total 24-hour and annual average impacts were multiplied by 3.53/3.2 to obtain revised totals for those two averaging periods.

The modeling results in Table 5-7 show compliance with the 3-hour, 24-hour and annual average NAAQS when Warren Station operates at SO_2 emission rates of 4.00 lbs/MMBtu for the 3-hour averaging period and 3.53 lbs/MMBtu for the 24-hour and annual averaging period.

Tables 5-8 and 5-9 summarize the results of the revised NAAQS compliance demonstration. *The only SO_2 emission rate limit required to comply with any NAAQS is 3.53 lbs/MMBtu to meet the 24-hour average NAAQS when both Warren Station units are operated simultaneously.* (Although it is not required to comply with the annual average NAAQS, the 24-hour average emission rate limit would also become the yearly limit since the annual average emission rate cannot exceed the daily limit)

Table 5–6a
Recalculation of the Warren Station Annual SO_2 Emission Limit Based on the Hybrid Modeling Results for the Receptors with Predicted NAAQS Violations in Table 4–3 (Both Warren Station Units Operating)

LAPPES Receptor Number	Julian Date	SO_2 Concentrations: Warren Station (LAPPES) [a]	United Refining (RTDM)	United Refining (CTSCREEN) [b]	Subtotal [c]	Back–ground	Total	Required Percent Reduction
170	N/A	26.7	46.1	36.6	63.3	11.8	75.1	0.0
172	N/A	27.6	49.9	33.8	61.4	11.8	73.2	0.0
173	N/A	29.1	52.1	35.2	64.3	11.8	76.1	0.0
174	N/A	28.8	54.8	33.3	62.1	11.8	73.9	0.0

[a] at an SO_2 emission rate of 4.00 lbs/MMBtu.
[b] see Table 5–3.
[c] LAPPES + CTSCREEN.

N/A = not applicable

Table 5–6b
Recalculation of the Warren Station Annual SO_2 Emission Limit Based on the Hybrid Modeling Results for the Receptors with Predicted NAAQS Violations in Table 4–6 (Warren Station Unit One or Two Operating)

LAPPES Receptor Number	Julian Date	SO_2 Concentrations: Warren Station (LAPPES) [a]	United Refining (RTDM)	United Refining (CTSCREEN) [b]	Subtotal [c]	Back–ground	Total	Required Percent Reduction
172	N/A	21.2	49.9	33.8	55.0	11.8	66.8	0.0
173	N/A	22.1	52.1	35.2	57.3	11.8	69.1	0.0
174	N/A	21.6	54.8	33.3	54.9	11.8	66.7	0.0

[a] at an SO_2 emission rate of 4.00 lbs/MMBtu.
[b] see Table 5–3.
[c] LAPPES + CTSCREEN.

N/A = not applicable

Table 5–7
Recalculation of Maximum SO_2 Concentrations
on DEP CTSCREEN Hill Nos. 3 to 5

Hill No.	Stability [b]	Model	Warren Station @ 3.2 lbs/MMBtu [a] 1–hour	3–hour	24–hour	Annual
Background [c]	S	N/A	N/A	76	79	18
	U	N/A	N/A	56	40	18
3	S	CTSCREEN	844	667	206	43.3
	U	CTSCREEN	1090	819	203	50.7
4 & 5	S	CTSCREEN	829	656	203	42.9
	U	CTSCREEN	840	644	166	43.2

Hill No.	Stability [b]	Model	Warren Station @ 4.00 or 3.53 lbs/MMBtu [d] 1–hour	3–hour	24–hour	Annual
Background [c]	S	N/A	N/A	76	79	18
	U	N/A	N/A	56	40	18
3	S	CTSCREEN	1055	815	237	49.7
	U	CTSCREEN	1362	1009	244	58.9
4 & 5	S	CTSCREEN	1036	801	234	49.1
	U	CTSCREEN	1050	791	198	49.5

[a] predicted concentrations due to Warren Station and United Refining combined, as shown in DEP's January 3, 1996 report (the 3–hour, 24–hour and annual average concentrations shown here include the background concentrations).

[b] S indicates stable/neutral, U indicates unstable.

[c] values shown in DEP's January 3, 1995 report.

[d] based on the extremely conservative assumption that each model–predicted impact was due solely to Warren Station (i.e., each 3–hour average impact at 4.00 lbs/MMBtu = 4.0/3.2 * the impact at 3.2 lbs/MMBtu, and each 24–hour and annual average impact at 3.53 lbs/MMBtu = 3.53/3.2 * the impact at 3.2 lbs/MMBtu).

Table 5–8

Summary of the Maximum Source Impacts and SO_2 Concentrations and and Calculation of the Required Percent Emission Rate Reductions for Warren Station (Both Warren Station Units Operating) [a]

Averaging Period	LAPPES Receptor Number	SO_2 Concentrations ($\mu g/m^3$) Warren @ 4.0 lb/MMBtu	United Refining	Background	Total	NAAQS	Percent Reduction Required
3–hour	173	106.03	752.33	10.5	868.86	1300	0.0
24–hour	149	395.83	0	15.3	411.13	365	11.7
Annual [b]	173	29.10	35.15	11.8	76.05	80	0.0

[a] this table shows the highest second high concentrations to which Warren Station contributes (since the United Refining contribution predicted by CTSCREEN is constant).
[b] the maximum values are shown for the annual averaging period.

Averaging Period	Allowable Warren Emission Rate (lb/MMBtu)
3–hour	4.00
24–hour	3.53
Annual	4.00

Table 5–9

Summary of the Maximum Source Impacts and SO_2 Concentrations and Calculation of the Required Percent Emission Rate Reductions for Warren Station (Only One Warren Station Unit Operating) [a]

Averaging Period	LAPPES Receptor Number	SO_2 Concentrations ($\mu g/m^3$) Warren @ 4.0 lb/MMBtu	United Refining	Background	Total	NAAQS	Percent Reduction Required
3–hour	173	56.65	752.33	10.5	819.48	1300	0.0
24–hour	174	7.39	166.36	11.2	184.95	365	0.0
Annual [b]	173	22.10	35.20	11.8	69.10	80	0.0

[a] this table shows the highest second high concentrations to which Warren Station contributes. (since the United Refining contribution predicted by CTSCREEN is constant).
[b] the maximum values are shown for the annual averaging period.

Averaging Period	Allowable Warren Emission Rate (lb/MMBtu)
3–hour	4.00
24–hour	4.00
Annual	4.00

6.0 REFERENCES

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